Cross-speaker covariation across six vocalic changes in New York City English

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Abstract

This article examines differences in the way that innovative variants for six vocalic changes in New York City English—TOO-fronting, raising of PRICE and FACE and lowering of BAD, THOUGHT and DRESS—co-occur across speakers, and explores social correlates of these patterns of covariation. We report on an analysis of a recently developed corpus of conversational speech from 140 speakers. The analysis suggests that patterns of covariation across speakers is conditioned by the local social embedding of the changes. Changes affecting highly localized realizations for raised BAD and THOUGHT are distributed differently from supra-local changes affecting TOO and DRESS.

1 Introduction

A recurring finding in recent sociolinguistic research is that processes of change in a given community often exhibit different patterns of co-occurrence across speakers conditioned by locally defined sets of meanings. Based on an analysis of cross-speaker covariation in six vowels in Philadelphia English, Tamminga (2019) reports that the three features showing significant pairwise correlations are all sound change reversals, plausibly motivated by avoidance of local forms highly emblematic of local speech. Similarly, Becker (2016) suggests that covariation in THOUGHT-lowering and rhoticity in New York City English reflect in part speakers' disalignment with a "classic New Yorker" persona. Likewise, Newlin-Łukowicz (2016) reports that co-occurrence of TH-stopping, THOUGHT-raising and traditional short-a forms in English among New York City Poles correlates with different orientations to Polish New York, America and Poland. This article builds on these results, examining patterns of covariation in six vocalic changes in New York City English.

Over the past decade, severals independent studies have described decline in use of traditional vocalic features of New York City English (NYCE). Most of this work has focused on one of two changes—lowering of THOUGHT and the phonological reorganization of the short-a system (Becker and Wong, 2010; Becker, 2009, 2014; Newman, 2014; Wong, 2007, 2010, 2014; Wong and Hall-Lew, 2014; Newlin-Łukowicz, 2016; Coggshall, 2017; Shapp, 2019). In this paper, we examine change in these two lexical sets (focusing specifically on BAD[1] for short-a sounds) alongside four other vocalic shifts that have received less attention in the literature on NYCE, namely changes affecting PRICE, FACE, DRESS and TOO. In particular,

[1]Contexts before tautosyllabic voiced stops and voiceless fricatives, following Becker's (2016) labeling.

we examine social correlates of covariation across these six shifts in an effort to describe different ways that meanings of ethnicity, age and place are affecting the course of these changes. The data we report on here are drawn from a corpus of conversational speech from 140 native speakers of New York City English consisting of just over 112,000 tokens.

Our results suggest that patterns of covariation are shaped by the local social embedding of changes. In particular, while young white speakers are conservative with respect to THOUGHT and short-a sets—linked in much previous literature to traditional white working class New York City personas (Becker, 2010, 2014, 2016; Becker and Wong, 2010; Newlin-Łukowicz, 2016)—younger whites are also leading changes toward supra-local features including DRESS-lowering and TOO-fronting. Conversely, non-White groups, particularly younger Latinx and Asian participants, are diverging sharply from raised THOUGHT and BAD, but trail in adoption of innovative forms for TOO and DRESS. From one perspective, then, our results align with other recent findings of "incoherence" across innovations in speech communities, i.e. that individuals' rates of participation in different changes in a community are largely non-uniform (Guy, 2013; Oushiro and Guy, 2015; Waters and Tagliamonte, 2017; Tamminga, 2019, to appear). At the same time, these patterns of covariation show clear social conditioning that align with recent results linking certain of these changes to meanings of age, gender and place (Becker, 2010, 2014; Wong, 2014; Wong and Hall-Lew, 2014).

Our discussion is organized as follows. In section 2, we describe the data set reported on in this paper and the analysis used. Section 3 describes each of the six patterns of change considered here. Section 4 discusses results from a cluster analysis that illuminates the social patterning of (non-)participation in these vocalic changes.

2 Data

The data set used here were gathered through the CoNYCE project, a four-year project, currently in progress, to develop an audio-aligned and parsed corpus of spoken New York City English (Tortora et al., in progress). The sub-sample discussed here consists of audio recordings of 140 speakers with years of birth ranging from 1906 to 2001 (M =1977.9). 82 of these participants self-identified as women and 58 as men. All of the participants reported having lived in the greater New York area—the five boroughs, Nassau, Suffolk and Westchester counties of New York or northern New Jersey, from the age of nine or younger.

The distribution of participants by age and Ethnic category is summarized in Figure 1. Younger speakers were over-sampled in an effort to better describe patterns among younger New Yorkers. While vocalic patterns for older speakers are well described in extensive work dating back several decades (Trager, 1930, 1934, 1940; Labov, 1966, 1972, 2007), much less description exists for the novel vocalic patterns of younger New Yorkers and particularly younger New Yorkers of color, which we aim to address in part in this paper. Also noteworthy in Figure 1 is that Asian and Latinx participants in the study are younger on aggregate than Black and White participants, a fact that partially reflects demographic change in the city shaped by the Immigration and Nationality Act of 1965 (Hart-Cellar Act) (Foner, 2001; Anbinder, 2016; Becker and Coggshall, 2009). We discuss the implications of this imbalance for data modeling in Section 3.

The audio samples used here come from two sources. 135 of the samples are sociolinguistic

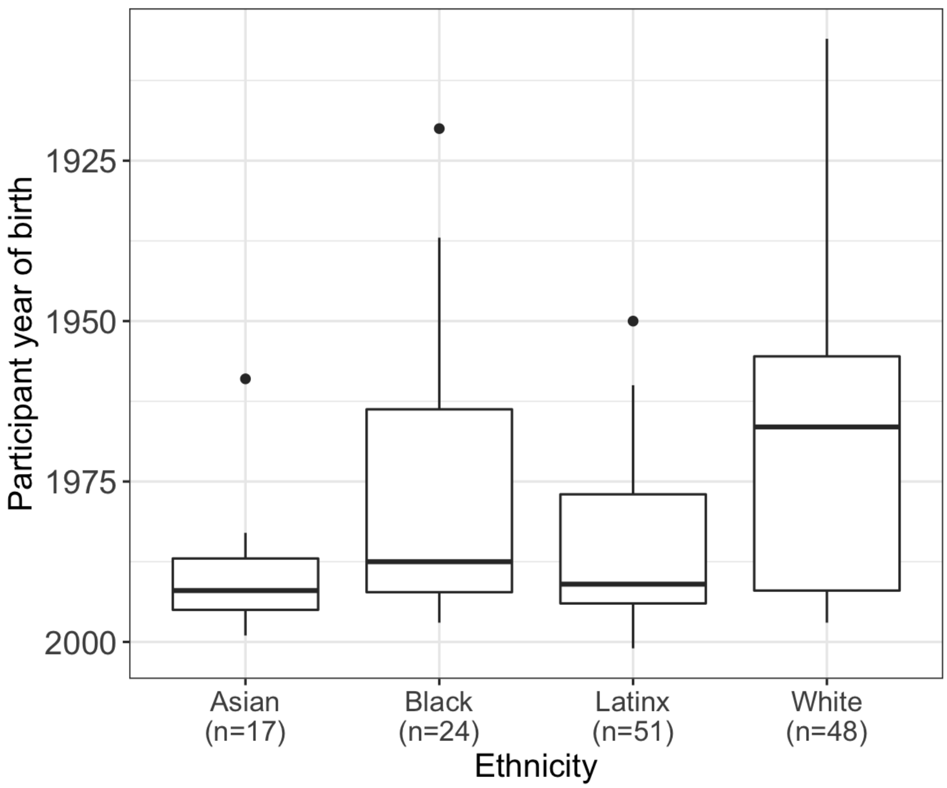


Figure 1: Distribution of sample participants by year of birth and ethnic category.

interviews gathered between 2015 and 2018 by undergraduate and graduate students at the City University of New York, trained by the project PIs. The interviews were based loosely on a template of questions focusing on childhood narratives and changes in the community, and concluding with a set of questions focusing on participants' perceptions of language use in New York and New York City accent features. These samples typically last between 30 and 60 minutes. These recordings were made using Zoom H4N digital recorders at a sampling rate of 44100 Hz. Nearly all of student workers on the project are themselves native members of greater NYC communities and typically recruited participants from their home communities. The other five samples are oral history interviews conducted during the 1980s through the Bronx Oral History Archive project, which have been incorporated into the CoNYCE data set.

Measurements for the first and second formant for each vowel in the data set were extracted using FAVE-Extract (Rosenfelder et al., 2014)[2] and Prosodylab-Aligner (Gorman et al., 2011), using the DARLA interface (Reddy and Stanford, 2015). We include only tokens bearing primary word stress and have excluded all contexts preceding coda /r/. Vowel measurements were normalized using Lobanov's procedure (Lobanov, 1971).

For each of the six lexical sets, we fit linear mixed effects regression models using the lme4 package (Bates et al., 2015) in R (R Core Team, 2014). P-values were estimated using Satterthwaite's method using lmerTest library in R (Kuznetsova et al., 2016). Variables in

[2]Measurement points were those used in FAVE default specifications.

Lexical Set	n
DRESS	25,824
FACE	27,044
BAD	4,481
PRICE	18,087
THOUGHT	20,741
TOO	16,149

Table 1: Token numbers by lexical set

the model were selected using a step-up procedure with models compared via likelihood ratio tests. Candidate variables for selection were those in (1), chosen based on analysis of the data and previous work on NYCE. For each of the six lexical sets considered here except THOUGHT and short-a change, we summarize analyses of social and linguistic predictors on these processes of change in Section 3. The latter lexical sets are well described in the recent diachronic literature on NYCE and, for reasons of space, we do not discuss our replications of these results here.

(1)
- Age (in 2020)
- Ethnicity[3]
- Parent first dialect[4]
- Gender
- Scaled occupational prestige[5]
- Preceding sound
- Following sound
- Decadic log of vowel duration (seconds)
- Decadic log of word frequency[6]

To identify patterns of common realizations across these six sets, we use a Diana clustering procedure, a divisive clustering technique (Kauffman and Rousseeuw, 1990). Unlike agglomerative techniques which assign items to clusters by merging nodes bottom-to-top, divisive techniques start with the entire data set as a single cluster and divide clusters into nested sets of terminal nodes and binary branching non-terminal node. This technique is

[3]The ethnic category labels are aggregations based on participants' self described ethnicity. The categories used are motivated based on previous work on ethnicity and change in NYCE (see references throughout). The group *Asian* includes participants who identify with East Asian and South Asian ancestry, who participate similarly in the processes of change considered here. *Black* includes participants self identifying as African American or Afro-Caribbean.

[4]Participants were coded for whether at least one parent is NYCE-native. Preliminary revealed this to be a more predictive measure than one that separates participants based on whehter both parents are NYCE-native.

[5]Subjects were coded on a five-point scale following Baranowski and Turton (2018). 1=Unskilled laborers. 2=skilled laborers. 3=lower white collar, retail and current university students. 4=lower professionals including teachers, engineers and manager. 5=higher professional occupations.

[6]Frequencies were taken from the Subtlex corpus (Brysbaert and New, 2009).

particularly well suited to identifying higher-level splits in the data, the primary focus our analysis. The clustering is based on by-participant estimates for each of these six sets adapting an approach from Tamminga (2019, to appear). For each of the six sets, LMER models were fit with a structure in (2). The predictors in the model are used only to control for linguistic conditioning effects, and no participant-related predictors or random terms are included. From each of these models we extracted residuals—the error not accounted for in the models—and use the by-participant means of these measures for the clustering algorithm. These by-participant means were then scaled to balance the influence of each lexical set on distance measurements.[7] Distances between speakers using values for each of six lexical sets were computed using the Euclidean distance method, i.e. the square root of the sum of differences.[8]

(2) [F1/F2/Front diagonal] $\sim$ Preceding sound + Following sound + Log_{10}(duration) + Log_{10}(Word frequency+1) + (1 | Word)[9]

The clustering technique just described therefore provides a representation of overall similarity between sets of speakers in vocalic production across these six features. To assess the *social patterning* of covariation across these changes, we sought to avoid tuples of features for which covariation could plausibly be attributed to structural rather than social factors. Oushiro and Guy (2015), for example, found that covariation across six features (15 pairwise comparisons) was determined in part by structural relationships among the variables. (See also Guy (2013).) Similarly, cross-speaker covariation across vocalic features implicated in chain shifts is described in an extensive body of results (Eckert, 2000; Watt, 2000; Haddican et al., 2013; Fruehwald, 2013; Kendall and Fridland, 2017; Fridland and Kendall, 2019; Becker, 2019b). For these reasons, the analysis below includes vocalic changes that are phonologically independent. We describe these in greater detail in the following section.

3 Six vocalic changes

3.1 TOO-fronting

New York City English (NYCE) has generally been described as conservative with respect to the fronting of high back vowels across contexts (Labov et al., 2005). More recently, however, three studies have reported evidence of fronting in certain contexts and speaker groups. Newman (2014), reports some fronting of post-coronal /u/ (TOO), particularly among White and Asian speakers. Similarly, Wong (2014) finds some fronting of HOOP (non-post-coronal, non-pre-lateral /u/) among younger Chinese-Americans. Most recently, Haddican et al. (2019),

[7] Mean values were centered and then divided by the standard deviation for each set.

[8] That is:

(i)

$$\sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

[9] For the model of TOO, Preceding sound was not included as a control predictor.

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	0.562	0.138	102.614	4.066	0.000
Age	-0.017	0.004	81.110	-4.017	0.000
Following: lab., [+back][10]	-0.140	0.019	109.459	-7.192	0.000
Log$_{10}$ ***(duration)***	0.182	0.023	8434.120	7.904	0.000
Ethnicity: Asian	0.234	0.063	81.808	3.717	0.000
Black	0.050	0.068	80.672	0.735	0.465
White	0.319	0.059	81.423	5.378	0.000

Table 2: Summary of an LMER model of F2 for TOO. Model formula: F2 ∼ Age + Following sound + Log Duration + Ethnicity+(Following sound | Speaker)+(1 | Word). Obs.=8720, N=88. Reference levels: *[Back]* for following sound and *Latinx* for Ethnicity.)

based on conversational speech samples from 97 native NYCE speakers, report evidence of fronting of TOO, HOOP, FOOT and GOAT, in a pattern similar to that described for California English (Eckert, 2008; Hall-Lew, 2009; Podesva, 2011; Podesva et al., 2015; Cheng, 2016). In their data, fronting across these lexical sets correlates strongly across speakers suggesting a single abstract process of back vowel fronting affecting these four contexts.

Again, because the focus of our analysis is on the social patterning of phonologically independent vocalic changes, we do not consider all four of these high back lexical sets (which are indeed all undergoing fronting in our data set) but instead focus on one—TOO—which affords a robust quantity of observations/participant (M =101). We begin by summarizing an LMER model of TOO-fronting in Table 2. The results here are based on an 88-speaker subset, excluding participants born before 1972, which provides a sample more appropriately balanced for age and ethnicity. As noted above, the oldest tranche of our sample is almost exclusively White and Black, and largely excludes Asian and Latinx participants. We remove older participants' data in most of the models summarized in this section, but include it in the cluster analysis presented in Section 4.

The summary in Table 2 lists first a negative effect of age, with older participants favoring, as expected, lower F2 values. Following this are effects of following sound and duration, which we do not dwell on here. Finally, the analysis reveals an effect of ethnicity with younger Asian and White participants tending toward fronter realizations relative to Latinx participants (the reference level), a pattern previously reported in Newman (2014). The analysis revealed no main effects nor interactions for participant gender, occupation level nor parent first dialect.

Importantly, Table 2's representation of the effect of participant age on TOO-fronting as linear is misleading. Figure 2, below, which plots by-participant F2 means by participant year of birth, shows that fronting of TOO accelerates sharply with participants born in the 1980s. To better measure the point of inflection in this change, we fit a series of models with breakpoints that effectively model two different slopes for participant year of birth—one before a specified year, and one after. To identify the optimal breakpoint, we fit one model for each year of birth in the sample (1906-2001), and selected as the optimal model that with the smallest total deviance between fitted and observed values (Baayen, 2008). This procedure yields a breakpoint at 1989, indicated by the vertical blue line in Figure 2. We

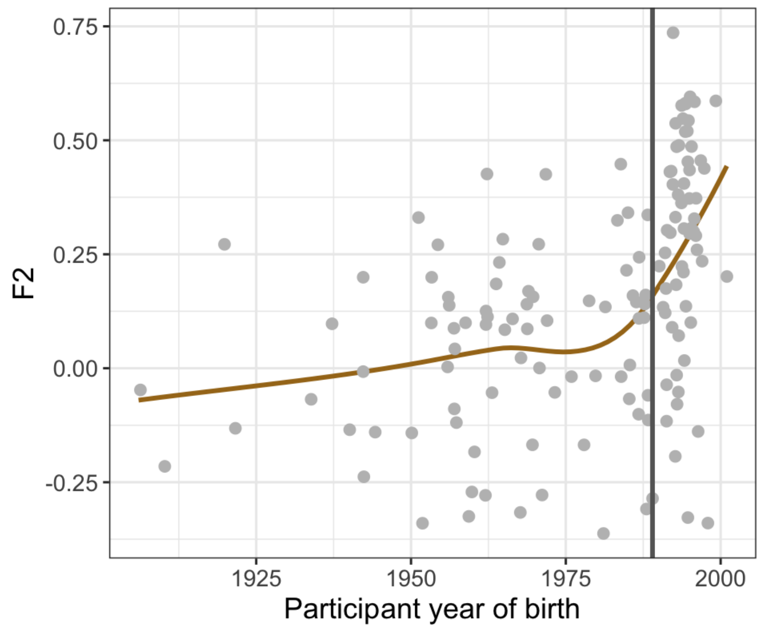


Figure 2: Mean F2 for TOO by participant year of birth.

return to these age effects on TOO shortly.

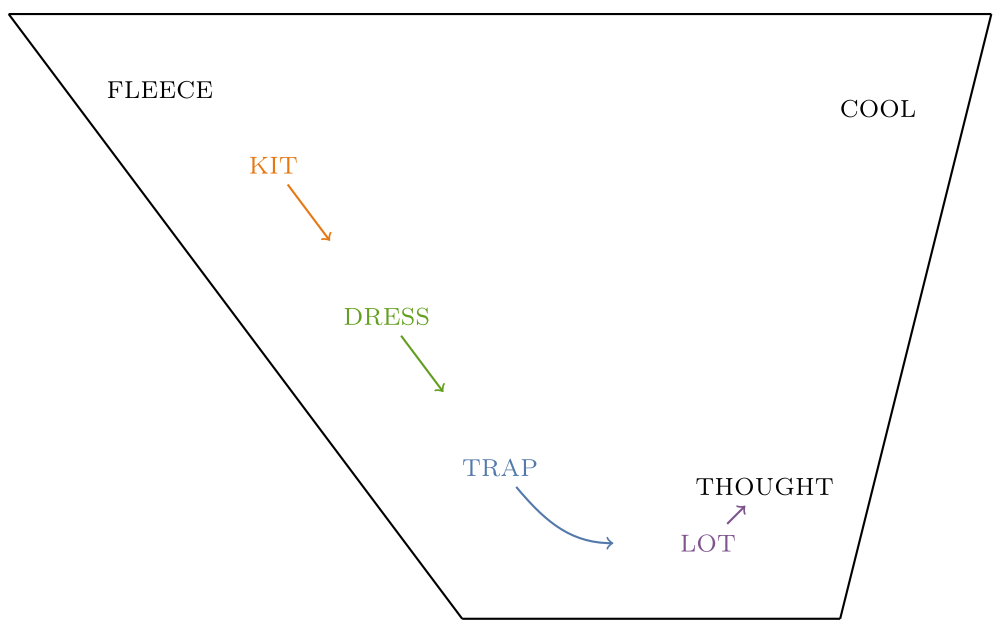
3.2 DRESS-lowering

Lowering of DRESS has been reported in several North American dialects principally as part of the California Vowel Shift (Eckert, 2008; Hall-Lew, 2009; Podesva, 2011; Podesva et al., 2015; Cheng, 2016), Canadian Shift (Clarke et al., 1995; Boberg, 2005; Hoffman, 2010) and Northern Cities Shift (Labov, 1994; Eckert, 2000; Wagner et al., 2016; D'Onofrio and Benheim, 2020; D'Onofrio, 2021). A growing body of recent work has proposed treating the first of these two shifts as a unified phenomenon—termed the "Low back merger shift" in Becker (2019b)—in view of the similar patterns of shift across low and front short vowels, KIT, DRESS, TRAP and LOT (Clarke et al., 1995; Becker, 2019a; Boberg, 2019). In particular, (Becker, 2019a), building on proposals by Thomas (2001); Gordon (2004) and Labov et al. (2005), proposes that merger of LOT and THOUGHT classes creates "instability" in the short vowel system which leads to a pull chain affecting TRAP, DRESS and KIT.

No reports that we are aware of have described an appreciable presence of LOT-THOUGHT merger in production data in New York City English, though Johnson (2007) and Haddican et al. (2016a) report some evidence of merger in homophony judgment data. The fact that the younger speakers in our data set who show shifting of short vowels, generally show little evidence of a low back merger in production supports skepticism toward an approach that takes short vowel shifting in NYCE to be "triggered" by a LOT-THOUGHT merger (Kendall and Fridland, 2017; Fridland and Kendall, 2019). Indeed, LOT-THOUGHT approximation in NYCE appears to be a product less of LOT-retraction than of THOUGHT lowering, which we consider shortly (Becker, 2010, 2014). In the remaining discussion, we set aside the issue of the LOT-THOUGHT merger as a triggering event.

In the present data set, DRESS lowering correlates across participants with backing of TRAP and LOT, and lowering/backing of KIT, suggesting the possibility of a chain-like shift affecting these neighboring short vowels.[11] Again, because our focus is the social patterning of independent processes of change, we do not include all three of these lexical sets in the analysis, but instead choose DRESS, as the set with the greatest number of observations/participant (M=186). We are aware of no evidence from speaker perceptions suggesting differences in the indexical values of these shifts in the NYCE case.[12]

(3) ***The low back merger shift in North America***



We begin with a summary of an LMER model in Table 3. DRESS vowels are lowering along the front diagonal and we therefore use F2-F1 (hereafter "diagonal") as the dependent measure. (For convenience, we refer to this change simply as "lowering".) Table 3 lists first an effect of participant age with older participants tending toward raised realizations. Preceding velar sounds and high front vowels favor higher realizations, while preceding labials, liquids and back vowels favor lower realizations. (See Eckert (2000) and Hall-Lew et al. (2015) for descriptions of similar effects in other North American varieties.) Lowering is also favored by following bilabials and [l, ʃ, ʒ]. Lowering is led by women and by White participants, with Black participants favoring more conservative realizations.

Finally, as in the case of TOO-fronting, the linear treatment of the effect of participant age on DRESS-lowering is misleading. Figure 3 shows a precipitous break for front diagonal values, for speakers born in the late 1970s. Applying the procedure described above reveals an optimal breakpoint at 1978, as shown in the plot.

[11]The relevant TRAP contexts here are short-a vowels not involved in the phonological reorganization away from the traditional NYCE split-pattern. We return to these facts shortly. See Haddican et al. (to appear) on the correlation between LOT and TRAP backing in NYCE.

[12]See D'Onofrio et al. (2019) on TRAP-backing and Valley Girl personae in California.

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	-0.870	0.104	111.302	-8.402	0.000
Age	0.011	0.003	76.700	4.012	0.000
Preceding: lab., liq, back vowels	-0.319	0.028	300.300	-11.260	0.000
Preceding: velars, front vowels	0.824	0.038	301.272	21.631	0.000
Log $_{10}$ ***(duration)***	-0.692	0.032	13983.290	-21.722	0.000
Following: Bilabials, [l, ʃ, ʒ]	-0.166	0.040	591.359	-4.092	0.000
Gender: Women	-0.115	0.032	82.556	-3.607	0.001
Ethnicity: Latinx	-0.163	0.045	77.723	-3.651	0.000
Asian	-0.174	0.053	80.685	-3.294	0.001
White	-0.218	0.050	77.600	-4.377	0.000

Table 3: Summary of an LMER model of F2-F1 (front diagonal) for DRESS. Model formula: Diagonal ∼ Age + Preceding sound * Gender + Log Duration + Following sound + Ethnicity + (Preceding sound + Following sound | Speaker)+ (1 | Word). Obs.=14,171, N=88. Reference levels: *other* for following sound, *other* for preceding sound and *Black* for ethnicity.

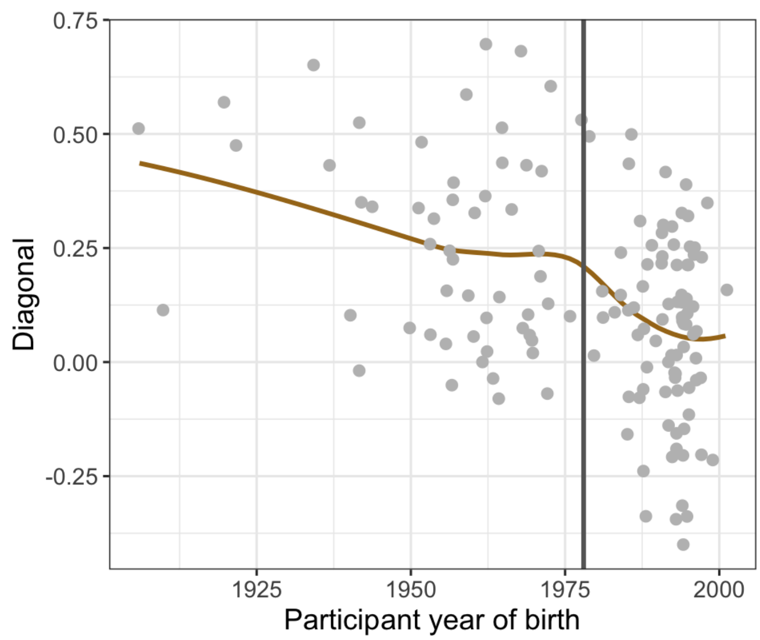


Figure 3: Mean front diagonal for DRESS by participant year of birth.

3.3 FACE-raising

A well described process of change in NYCE's mid-Atlantic neighbor, Philadelphia English, is raising of FACE in "checked" contexts, that is, those with a word internal following consonant (Labov, 2001; Labov et al., 2013; Fruehwald, 2013; Tamminga, 2019). FACE raises along the front diagonal in contexts with a word-internal following consonant (*rake, baker*), but not in word final "free" position, (*pay*).

Results from the present data set suggest a similar process of change in NYCE. Figure 4 shows a gradual increase in front diagonal values across the timespan included in the sample, for all contexts except surface free contexts (the pink line in the plot). Importantly, Figure 4 suggests that this process of change in NYCE shares several properties of the change in Philadelphia as described by Fruehwald (2013, ch. 5). First, the free/checked constraint is insensitive to syllable structure in that vowels in closed syllables (with a following coda consonant) behave like those in open syllables (with a following onset C) in terms of their effect on raising, as suggested by the similar smoother shapes for these contexts. Second, like in Philadelphia English, the free/checked constraint appears to be surface true in that vowels in underlyingly free contexts closed by morphological concatenation behave like vowels in checked contexts otherwise and unlike those in surface-free contexts. Third and finally, the data suggest that checked contexts with a following [l] may be diverging from elsewhere checked contexts in not participating fully in the change.

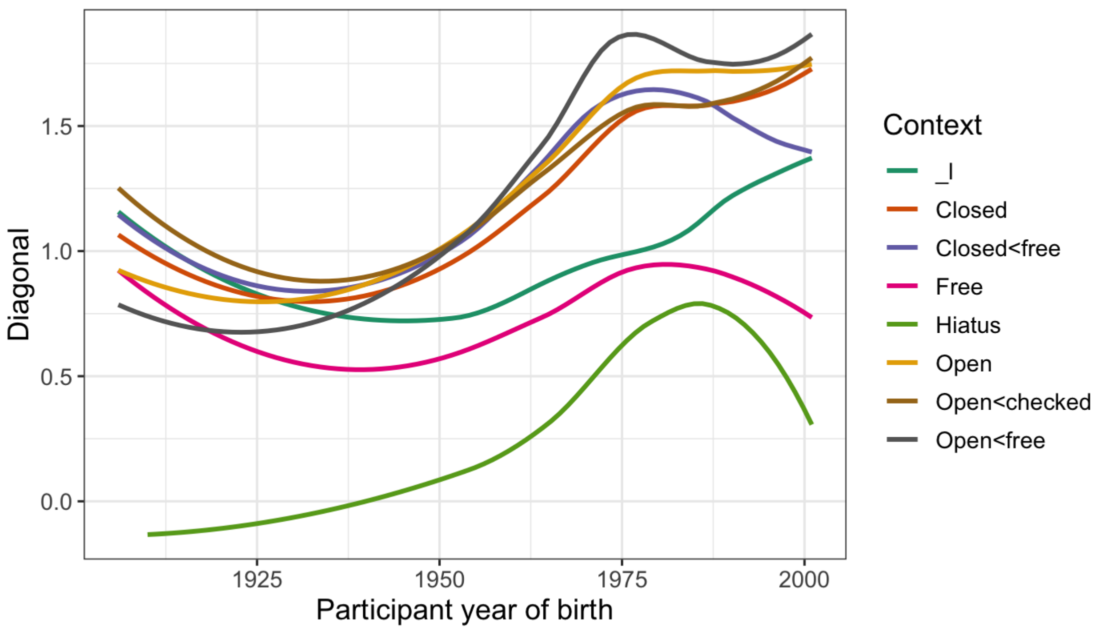


Figure 4: Mean front diagonal for FACE by context and participant year of birth.

We test the relationship between participant age and following context by fitting an LMER model to a sample subset. Figure 4 suggests that checked-FACE raising begins with participants born in the early part of the 20th century. Again, because the current data set is not balanced for participant ethnicity for the earliest years of birth (with White speakers oversampled), we fit a model only for the White participants (N=48). We return to effects of participant ethnicity on FACE later in the discussion. We also exclude from the modeling following [l] and hiatus contexts due to sparse data in these contexts.

We summarize the model in Table 4. The table shows an effect of preceding sound similar to that described for DRESS, above, with preceding velars and front vowels favoring raised realizations and preceding labials, liquids and back vowels favoring lower ones. Most importantly for our purposes, the model includes an interaction term between participant age and context, revealing a more steeply negative slope for participant age in checked contexts.

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	0.900	0.102	250.577	8.808	0.000
Context: Checked	1.034	0.107	210.154	9.668	0.000
Age	-0.003	0.001	37.853	-2.762	0.009
Preceding: lab., liq, back vowels	-0.474	0.041	144.382	-11.648	0.000
Preceding: velars, front vowels	0.433	0.044	115.741	9.801	0.000
Log_{10}(duration)	-0.281	0.035	8812.578	-8.043	0.000
Context:Age	-0.010	0.001	43.371	-8.003	0.000

Table 4: Summary of an LMER model of F2-F1 (front diagonal) for FACE. Model formula: Diagonal ∼ Context * Age + Preceding sound + Log Duration + (Preceding sound + Context | Speaker)+(1 | Word). Obs.=9031, N=48. Reference levels: *free* for context and *other* for preceding sound.

3.4 PRICE-raising

In NYCE, the nucleus of /aɪ/ in all contexts is traditionally low. Among conservative speakers, this nucleus is somewhat fronted before voiceless sounds and back elsewhere (Kaye, 2012; Newman, 2014). Newman et al. (2018), however, report evidence from spoken corpus data suggesting that this configuration is undergoing leveling to a Canadian Raising pattern described in some other parts of the northeastern US, with raised PRICE in all open checked syllables and in closed syllables before voiceless sounds but lowered PRIZE elsewhere.[13] So *spider* (open but checked syllable) and *spite* has PRICE (closed syllable closed by a voiceless sound). By contrast, *spy* (open free) and *pride* (closed with a voiced sound) have PRIZE. (Vance, 1987; Dailey-O'Cain, 1997; Hall, 2005; Kaye, 2012; Fruehwald, 2013; Tamminga, 2019, to appear).[14] We illustrate this in Figure 5, which shows change principally in F1 for PRICE items in both closed (*price*) and open syllables (*prices*).[15]

Table 5 summarizes an LMER model of normalized F1 for PRICE, for the 88-speaker subset of speakers born after 1972. The set of words included are those with PRICE vowels preceding a word-internal underlyingly voiceless sound. For the sake of brevity, we omit discussion of the phonetic predictors in the model, which are unremarkable. Among social predictors, we note an interaction between participant age and gender, with a considerably steeper age slope for women. This suggests that the change toward raised PRICE is progressing fastest among the women in the subsample. In addition, Table 5 shows an effect of participant ethnicity with Latinx and Asian participants leading the change, and White and Black participants favoring conservative variants.

[13] There is however some variation: the name *Heidi* can be pronounced either way as can *high school*.

[14] In the present data set, a parallel change is observed with MOUTH, that is with raised nuclei in pre-voiceless contexts among younger participants. The latter lexical set has fewer observations per participant (M=41.7), than does PRICE (M=130.1) and we focus on the latter in the remaining discussion.

[15] All but a handful of the open syllable items in our sample are underlyingly closed, so we cannot directly assess the effect of a morphological boundary as distinct from syllable structure in the data set. In perception, however, NYCE speakers typically report a *writer*/*rider* distinction (Fruehwald, 2013; Newman et al., 2018).

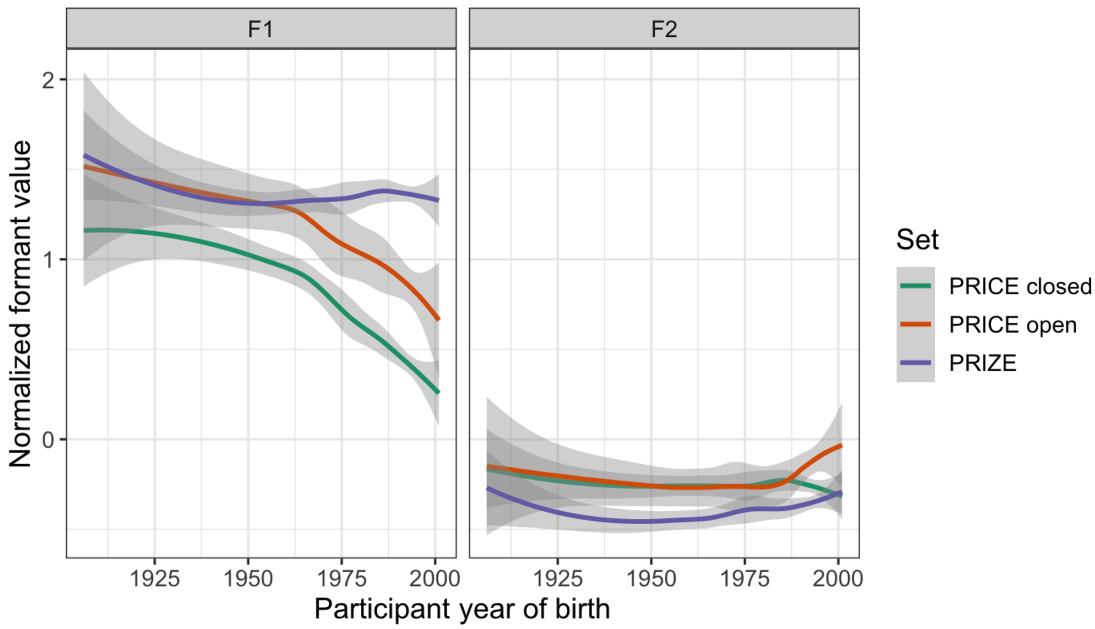


Figure 5: Mean formant values PRIZE and PRICE by participant year of birth.

3.5 THOUGHT-lowering

The final two lexical sets that we include in our analysis have been described extensively in recent literarture on NYCE. For space reasons, we do not report details of our replications of these core findings, but instead summarize the relevant reported facts.

We begin with THOUGHT, which, among conservative speakers, has a raised realization characteristic of many mid-Atlantic varieties (Labov, 1966; Labov et al., 2005, 2013; Newman, 2014). Over the past decade, however, several independent studies have reported evidence of lowering of THOUGHT in NYCE (Wong, 2007; Becker, 2010, 2014; Wong, 2010, 2012, 2014, 2015; Newman, 2014; Wong and Hall-Lew, 2014; Newlin-Łukowicz, 2015, 2016; Shapp, 2019). Becker (2010, 2014) reports that this this change is led by White and Asian speakers. While no reports have yet described broad prevalence of LOT-THOUGHT mergers in production, homophony judgment data by Johnson (2007) and Haddican et al. (2016b) support an expansion of the merger in perception, particularly among Asian and Latinx hearers. These findings are in keeping with Becker's (2014) matched-guise results suggesting raised THOUGHT is associated with older and White speakers. Similarly, in a recent phonemic perception study by Ortiz (2020), NYCE-native auditory judges were more likely to perceive merged realizations for LOT-variants in a minimal pair (e.g. [kɑt] as 'caught') when the auditory stimulus was accompanied by a photo of a Latina or Asian female face than that of a White female face.

A property that distinguishes raised THOUGHT from other conservative vocalic features considered here, is that it is a strongly emblematic of working class, white New York speech (Becker, 2014; Wong and Hall-Lew, 2014; Singler, 2017; Cutler, 2020). Wong and Hall-Lew (2014), in fact, suggest that the association of raised THOUGHT with "authentic" New Yorker

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	1.846	0.174	128.719	10.623	0.000
Following: [k]	-0.033	0.079	90.163	-0.424	0.672
Labials	0.164	0.082	86.833	2.004	0.048
Log_{10}(duration)	1.073	0.021	13894.021	50.713	0.000
Preceding: Labials	0.053	0.066	92.542	0.803	0.424
Other	0.344	0.082	132.772	4.188	0.000
Gender: Women	-0.681	0.197	74.497	-3.455	0.001
Age	0.004	0.005	69.738	0.932	0.354
Ethnicity: Asian	0.045	0.049	80.287	0.904	0.369
Black	0.142	0.053	76.095	2.686	0.009
White	0.119	0.046	77.816	2.556	0.013
Log_{10}(frequency)	-0.059	0.026	91.403	-2.282	0.025
Gender:Age	0.019	0.007	74.255	2.876	0.005

Table 5: Summary of an LMER model of F1 for PRICE for participants born >1972. Model formula: Diagonal∼Following sound + Log Duration + Preceding sound + Gender * Age + Ethnicity + Log.freq + (Preceding sound | Speaker) + (1 | Word). Obs.=13,971, N=88. Reference levels: *men* for gender, *Latinx* for ethnicity, *coronals* for Following sound and *coronal sonorants* for Preceding sound. A random slope for following sound by speaker was not fittable.

identities, largely associated with Whiteness is one reason many Chinese-Americans in New York avoid this feature. The possibility of a similar dynamic for other non-White groups in the NYCE speech community has not been addressed in the literature.

3.6 BAD-lowering

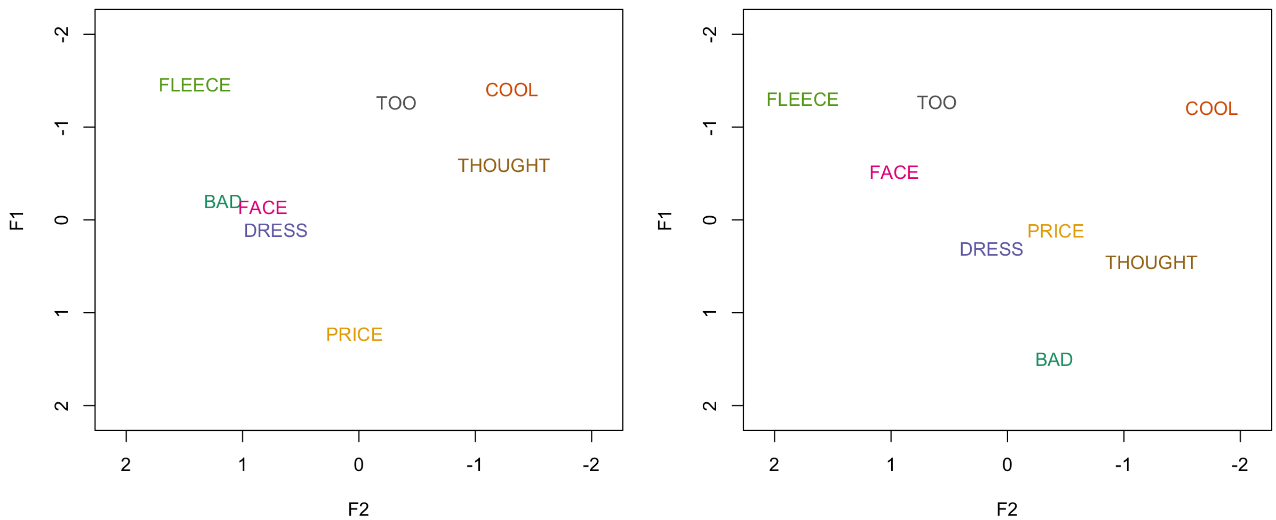
A second well-studied vocalic change in New York City English has to do with reorganization of the short-a system in NYCE. As described in an extensive body of 20th century literature, NYCE, since at least the late nineteenth century, has had a phonemic split between tense and lax short-a lexical sets with the former higher along the front diagonal and sometimes ingliding, [æ̝] or [ɛə], and the latter low and front, [æ] (Trager, 1930, 1934, 1940; Labov, 1966, 1972, 2007). Over the past decade, however, several independent studies have described a change away from this phonemic split to one of several different allophonic systems (Becker, 2010, 2016; Becker and Wong, 2010; Newman, 2014; Newlin-Łukowicz, 2015, 2016; Coggshall, 2017; Shapp, 2018; Haddican et al., to appear). Common to all of these descriptions is a process of lowering in a subset of erstwhile tense contexts—those in closed syllables before voiceless fricatives and voiced stops—yielding a merger with lax TRAP. The change is strongly correlated with speaker ethnicity with non-White speakers leading the change (Becker and Wong, 2010; Becker, 2010; Coggshall, 2017; Haddican et al., to appear). In the analysis presented below, we focus on this subset of contexts undergoing lowering.[16]

[16] The authors are grateful to Benji Wald for help with judgments on individual items and for guidance on various issues related to change in short-a.

We denote these as BAD, following Becker (2016).

3.7 Interim summary

We summarize the six changes just introduced by comparing, in Figure 6, patterns for two speakers, one instantiating robustly convservative variants, and the other innovative realizations. The panel on the left plots mean F1 and F2 values for the above six vowels for an older Italian American man (b. 1959) originally from Brooklyn. Note, here, that BAD is high and advanced, there is little contrast between DRESS and FACE, THOUGHT is raised, TOO is mid-advanced and PRICE is low. The panel on the right shows the corresponding measurements for an Asian American woman born forty years later. Here, in contrast, BAD is considerably lower and retracted, DRESS and FACE have diverged, THOUGHT has lowered, TOO is quite advanced and PRICE is raised.



(a) Conservative speaker, White man, b. 1959. (b) Innovative speaker, Asian woman, b. 1999.

Figure 6: Mean normalized F1 and F2 values from eight lexical sets for a conservative speaker (panel (a)) and an innovative speaker (panel (b)). Values for FLEECE and COOL, which are not included in the present analysis, are provided for reference.

In the two-speaker subset represented in these plots, co-occurrence of these six features is clear: innovative variants co-occur in one speaker's data and conservative variants in the other's. As we will see shortly, across the larger 140-speaker sample, there is greater variability, in that not all speakers participate in these changes to the same degree. This fact, indeed, is foreshadowed by the divergent effects of social predictors in the models just summarized. Our goal in the remaining discussion is to describe these co-occurrence patterns, with particular focus on two issues: (i) to what extent these six vocalic features correlate across speakers in our sample, and (ii) whether patterns of co-occurrence have discernable social correlates.

4 Social correlates of covariation

We begin with the first of these issues—the degree to which vocalic innovations co-occur across participants in the sample. Figure 7 plots a matrix of Spearman's rho values for the fifteen pairwise relationships among the six vocalic changes. Positive relationships are hued red and negative relationships blue, with color intensity denoting relationship strength. The p-values shown are unadjusted for multiple comparisons.

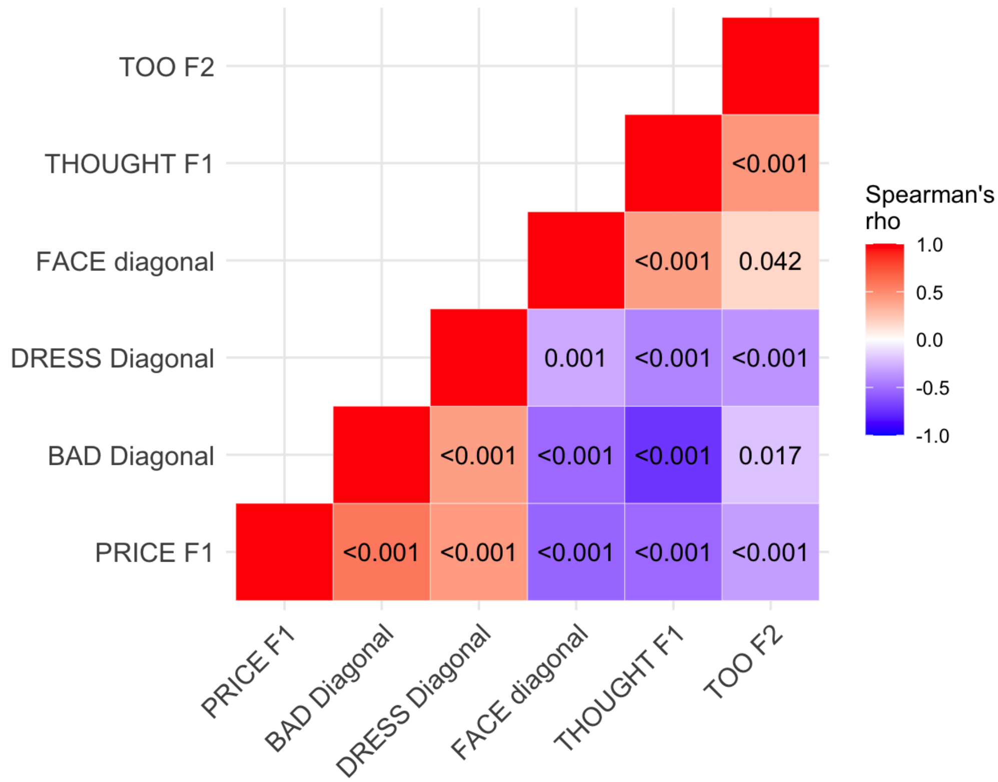


Figure 7: A matrix of Spearman's rho values showing cross-speaker correlations for six vocalic changes. N=138. P-values shown for rho < 1.

Somewhat unremarkably, given that all of these features are correlated with speaker age, all of the pairwise relationships are significant. As reflected in the figure, however, they differ considerably in strength. The strongest of these is that between the two NYCE shibboleth features—THOUGHT (F1) and BAD (front diagonal)—with a rho of -.73, suggesting a fairly strong co-occurrence across speakers (Labov, 1966; Becker, 2016; Newlin-Łukowicz, 2016). The other pairwise relationships, however, are all moderate or weak (for all, $|\text{rho}|<.59$), suggesting considerable variation in the way these features are distributed across speakers.

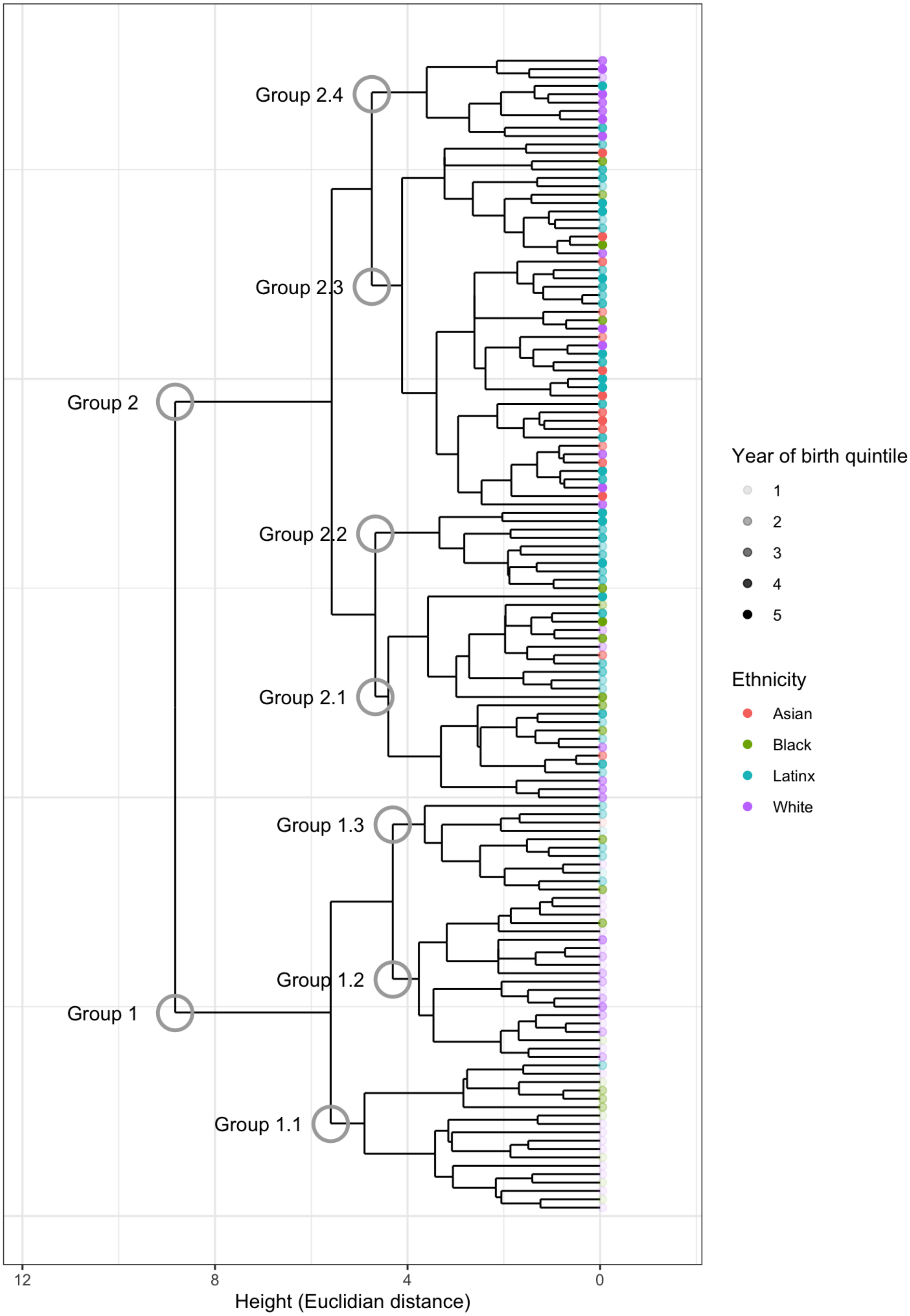


Figure 8: Dendrogram of a divisive cluster analysis. N=138.

At issue, then, is how these features cluster across speakers and whether these clusters have social correlates. We address this issue via a cluster analysis summarized in the dendrogram in Figure 8. The cluster analysis identifies groups of participants with similar sets of measurements across these six vowels. It allows social correlates of covariation across these six sets to emerge from the data unlike in regression modeling, where social predictors must be chosen *a priori.* In the present data set, cluster membership correlates strongly with participant age and ethnicity. The points at 0 along the x-axis are individual participants color coded by ethnic category. Shading denotes quintile of participant year of birth, with younger speakers more darkly hued[17]. The points corresponding to each participant are terminal nodes, and each higher level node connects two sets of speakers. The length of each branch corresponds to the Euclidean distance (square root of sum of squares of difference) between the vocalic measurements for the two nodes. Each node, therefore, represents, for its two daughter nodes, relative (dis-)similarity in by-participant measurements for these six vowels, i.e. the higher the node, the more dissimilar the two clusters joined.

The highest level split in the analysis distinguishes two sets of participants labeled Group 1 and Group 2 in Figure 8. As reflected in the figure, a principal social correlate of this split is participant age, with a median year of birth of 1957.2 for Set 1 and 1989.3 for Group 2 ($t(60.4)=11.48$, $p<.0001$). We consider these two main groups in turn.

Within the older group, three principal subsets—labeled 1.1-1.3 in the Figure—bear discussion. The first of these, a set of 18 participants, is the most conservative, and, on aggregate, the oldest set of participants in the sample with a mean year of birth of 1949.1. These are mainly White (9) and Black (8) participants reflecting the imbalance of ethnic category among older participants in the sample. Typical of this group of speakers are the conservative realizations shown in Figure 6a, and discussed in section 3.7. The clusterings in Figure 8, however, are not based on these raw normalized values but rather on by-speaker means of model residuals (see Section 2), and in the discussion to follow we therefore discuss these distributions. These measurements for Group 1.1 are presented in Figure 9, which shows conservative values for each of the six lexical sets: high values for DRESS and BAD diagonals and PRICE F1, and low values for FACE diagonal, THOUGHT F1 and TOO F2.

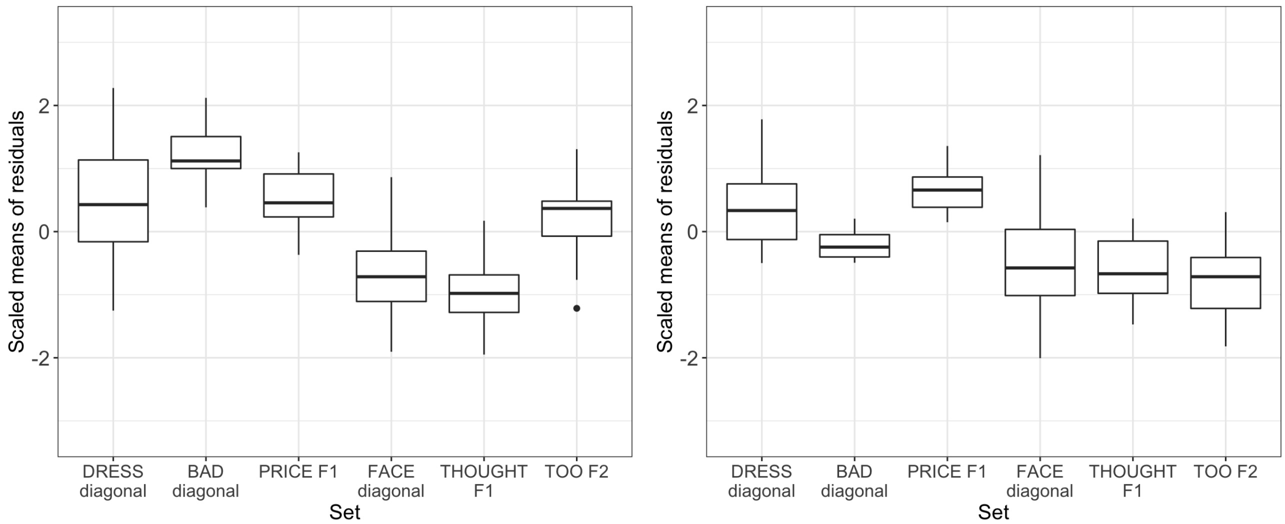
[17]We use age quintile only to make the distribution of speaker ages better visible in the plot.

Figure 9: Scaled means of residuals for six lexical sets for Group 1.1. N=18.

The sister of the node dominating Group 1.1 splits into two daughter nodes labeled 1.2 and 1.3 in Figure 8. These two clusters, together containing 31 participants, are distinguished principally by ethnicity, with Group 1.2 predominantly White (18 White, 2 Black), and Group 1.3 largely Latinx (7 Latinx, 2 Black, 1 Asian, 1 White). The former is also somewhat older on aggregate with mean years of birth 1958.8 and 1967.8, respectively (n.s.). We plot the distributions for these two sets in Figure 10, showing that both groups adhere largely to conservative variants, but with some movement away from the monolithically traditional patterns characteristic of Group 1.1. Change is clear across all six lexical sets, with the exception of Group 1.2's values for BAD. What principally distinguishes the two groups is which sets show the greatest change. Group 1.2 shows considerable change for all six sets, except for the two features most strongly associated with working class White speakers, namely raised variants for BAD and THOUGHT (Becker, 2010, 2014; Becker and Wong, 2010). Largely Latinx Group 1.3, on the other hand, is more conservative than group 1.2 overall, except for BAD and THOUGHT, for which Group 1.3 shows more innovative realizations on aggregate. Values for FACE are similar across the two groups.

These results, then, suggest patterns of targeted participation in vocalic change conditioned by ethnicity. It is not the case that the older White and Black participants of Group 1.2 are conservative across the board, but rather selectively so—participating readily in changes, except for those affecting forms most emblematic of local speech. These are, indeed, precisely the sets of forms eschewed by the largely non-White participants of Group

1.3. These results are in keeping with previous findings on ethnic group correlates of these two changes, with Latinx speakers leading lowering of BAD and THOUGHT (Becker and Wong, 2010; Becker, 2009; Haddican et al., to appear) and favoring conservative variants with respect to back vowel fronting (Fought, 1999; Newman, 2014). They are also reminiscent of Wong and Hall-Lew's proposal that Chinese New Yorkers avoid hyper-local raised THOUGHT in part because of its association with working class White speakers.



(a) Group 1.2. N=20.

(b) Group 1.3. N=11.

Figure 10: Scaled means of residuals for six lexical sets for Group 1.2 (panel (a)) and Group 1.3 (panel (b)).

The node labeled Group 2 branches to two groups, one containing Groups 2.1 and 2.2 (n=35) and the other containing groups 2.3 and 2.4 (n=54). The former is younger on aggregate, with mean years of birth 1984.9 and 1992.1, respectively (t(54.4)=3.78, p=.0004). As we will see shortly, the latter of these is also more innovative.

The older of these two groups contains two subsets labeled 2.1 and 2.2 on Figure 8. The former is somewhat older on aggregate with mean years of birth, 1983.0 and 1989.7, (t(27.5)=2.33, p=.0276). In addition, as reflected in the figure, the two groups are distinguished by ethnic composition: while Set 2.2 is almost entirely Latinx (with one Black participant), Group 2.1 is more variegated (11 Latinx, 6 Black, 6 White, 2 Asian). We illustrate the different distributions aggregated in these clusters in Figure 11.

Relative to their elders in Group 1, both sets show change across the six vocalic sets, with the exception of TOO, which shows little change. The clearest contrast between these two groups concerns the dramatically innovative values for FACE and conservative values for TOO in group 2.2. We note that conservatism with respect to TOO fronting was also observed for largely Latinx Group 1.3 in Figure 10b.

The final set of clusters that we consider are Groups 2.3 (44 participants) and 2.4 (10 participants), containing, on aggregate, the youngest speakers in our sample with mean years of birth 1992.1 and 1993.3 respectively. As reflected in the figure, these two groups differ in their ethnic composition. Eight of the ten participants in 2.4 are White, with the

(a) Group 2.1. N=25.

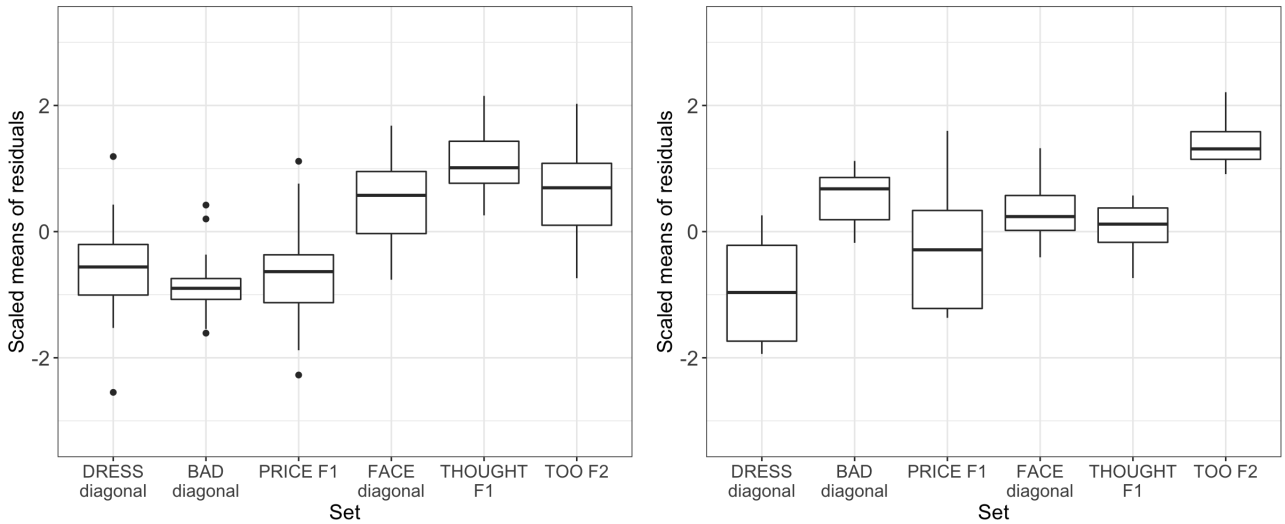
(b) Group 2.2. N=10.

Figure 11: Scaled means of residuals for six lexical sets for Group 2.1 (panel (a)) and Group 2.2 (panel (b)).

remaining two Latinx (one of whom identifies also as White). In addition, seven of these ten participants report that both of their parents themselves grew up in New York City. In contrast, Group 2.4 is ethnically mixed, but predominantly non-White: 21 Latinx, 13 Asian, 6 White and 4 Black. Of these 44 participants only six describe their parents as being native New Yorkers.

The distributions of residual means for these two groups are provided in Figure 12. The panel on the left, corresponding to Group 2.3 shows innovative patterns across all six lexical sets, akin to the pattern in the F1∼F2 plot in Figure 6b. Particularly notable are the extreme values for THOUGHT F1 and BAD diagonal. This set of speakers, then, constitutes the vanguard of movement away from raised BAD and THOUGHT. In contrast, the data for Group 2.4 in the right panel of Figure 12, show much more conservative values for both BAD and THOUGHT vis-à-vis those for Group 2.3. (Indeed, Group 2.4's values for BAD are even more conservative than those for their elders in Figure 11.) Importantly, while the participants in Group 2.4 are conservative with respect to BAD and THOUGHT, they are more innovative than Group 2.3 for two other changes: TOO fronting and DRESS lowering. These results are then reminiscent of the patterns observed for older participants in Figure 10. That is, this set of predominantly White speakers, like Group 1.2 is not globally conservative with respect to change, but rather selectively so—resisting change only for those accent features most strongly associated with working class New York City White speakers, namely raised BAD and THOUGHT. For supra-local TOO-fronting and DRESS-lowering, especially, the speakers in Group 2.4, indeed, are the leaders of innovation. Importantly, the constancy across time in the effects of ethnicity suggests no evidence of reorganization in patterns of covariation across the timespan represented in this sample. (See (Tamminga, to appear) for evidence of change in patterns of covariation in Philadelphia.)

The two panels in Figure 12, then, might be taken to instantiate two different ways of



(a) Group 2.3. N=44.

(b) Group 2.4. N=10.

Figure 12: Scaled means of residuals for six lexical sets for Group 2.3 (panel (a)) and Group 2.4 (panel (b)).

being young New Yorkers through accent features, each indexing different sets of meanings associated with age, ethnicity and place. Younger non-Whites (panel a) have moved sharply away from traditional local raised realizations for BAD and THOUGHT, a finding consistent with previous results (Becker, 2010, 2014; Becker and Wong, 2010; Coggshall, 2017; Shapp, 2018). In contrast, the younger White speakers (panel b) who are most conservative with respect to local features, are also those leading change toward innovative variants of supra-local TOO and DRESS. This mixing and matching of innovative forms is reminiscent of Watt's (2002) description of young Geordies' use of [ɵː] for GOAT—a compromise between traditional Geordie [ʊə] and Southern [oʊ], which Watt takes as a strategy for signaling a younger "modern" orientation without forsaking local roots.

Our results generally support recent findings suggesting considerable "incoherence" across innovations in a population—i.e. that it's typically not the case that speakers in a community are uniform in their participation in multiple unrelated changes (Guy, 2013; Oushiro and Guy, 2015; Becker, 2016; Waters and Tagliamonte, 2017; Tamminga, 2019, to appear). As the recent literature suggests, however, the presence vs. absence of covariation, may be, to a degree, predictable. Guy (2013) and Oushiro and Guy (2015) note that covariation is structurally constrained, i.e. is observed in pairs of features for which an abstract structural relationship exists. This possibility is also supported by the extensive literature on cross-speaker correlations in chain shifts (Eckert, 2000; Watt, 2000; Haddican et al., 2013; Fruehwald, 2013; Kendall and Fridland, 2017; Fridland and Kendall, 2019; Becker, 2019b). As discussed earlier, however, Tamminga (2019) suggests that patterns of covariation across variables are predictable from the social embedding of the linguistic features. In particular, Tamminga reports that the features exhibiting coherence across speakers all have the property of being localized features undergoing reversal. Similarly, Becker (2016) and Newlin-Łukowicz (2016), propose that co-occurrence of several different traditional NYCE accent features is constrained by meanings of authenticity and/or orientation to local vs. supra-local communities.

The results presented above align with results by Becker (2016), Newlin-Łukowicz (2016) and Tamminga (2019) in that the sets of features exhibiting the greatest cross-speaker covariation form natural classes, sociolinguistically speaking. More specifically, covariation appears to be conditioned by how and to what extent these vocalic features are locally indexed. Among younger speakers, the two highly localized features—raised BAD/THOUGHT covary—as do the two a-local "off the shelf" innovations broadly attested across North American varieties—DRESS-lowering and TOO-fronting (Milroy, 2009; Wong, 2014). The final two changes we have examined—PRICE and FACE-raising—are neither highly emblematic local features nor broadly distributed off the shelf changes, and do somewhat less work in discriminating between clusters.[18]

5 Conclusion

This paper has described patterns of cross-speaker covariation across six independent vocalic changes in New York City English. The results suggest that these variants are selectively recruited by participants in production in a way strongly conditioned by meanings of age, ethnicity and place in the community. Of the six vocalic changes described here, two in particular—raised THOUGHT and (to a lesser extent) raised BAD—have been reported in recent work to be strongly associated with traditional White working class New York City personas (Becker, 2014; Wong and Hall-Lew, 2014; Singler, 2017; Cutler, 2020). Values for these two features correlate strongly across participants in our study, with conservative variants favored by White participants in our sample. Importantly, however, White participants in our sample do not uniformly favor conservative variants and, indeed, across age groups, White speakers are leading in fronting of TOO and lowering of DRESS. Work on the way meanings of ethnicity, age and place condition change in lesser studied lexical sets in NYCE would benefit from further controlled experimental and ethnographic evidence, of the kind that has recently focused on THOUGHT (Becker, 2014; Singler, 2017; Cutler, 2020; Ortiz, 2020).

A further finding is that several of the changes currently taking place in NYCE are very similar to those described for its mid-Atlantic neighbor, Philadelphia English. Changes reorganizing the short-a system in the two cities have been observed to be similar in nature, but the two processes have not been compared in detail. (See, though, discussion in Haddican et al. (to appear).) The present results suggest that other changes including back vowel fronting, THOUGHT-lowering and FACE raising may also be shared across the two cities. The nature of the co-occurrence of these changes across the two urban populations warrants further study.

[18] See Tamminga (to appear) on the emergence of FACE-PRICE covariation in Philadelphia.

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